NAVY PERSONNEL RESEARCH AND DEVELOPMENT CENTER SAN DIEGO, CALIFORNIA 92152

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COMPUTATIONAL ACHIEVEMENT OF GROUP IV TRAINEES WITH A SELF-STUDY FORMAT: EFFECTS OF INTRODUCING AUDIO, WITHDRAWING ASSISTANCE, AND INCREASING TRAINING TIME

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A series of experiments was performed to determine levels of computational skills that could be achieved by Group IV trainees (personnel with marginally acceptable preinduction scores on the Armed Forces Qualifications Test) after training which utilized the Practical Arithmetic Self-Study (PASS) course. The effects of providing supplementary audio materials, decreasing assistance from instructors, and increasing training time were investigated. In general, PASS course training was found to be highly effective in the printed format.

Without direct assistance from instructors and with as little as 15 hours of instruction, the average level of performance was raised by approximately one full grade. Supplementing or replacing printed instructions with audio instructions produced no advantage. Extending training time to 24 hours allowed more trainees to complete the coursework and resulted in significantly higher gain scores. Criterion achievement was found to be related to initial levels of performance even for trainees who had completed most of the coursework. Implications of these findings are discussed with reference to the potential utilization of Group IV personnel.

FOREWORD

This research was performed under Work Unit Number MMPB SD.03 (Methodology for Efficient Training of Lower Mental Level Personnel). It was initiated in response to a request from the Department of Defense to determine the training potential of Navy Mental Group IV personnel. The data presented in the present study were collected over the period from May of 1969 through June of 1970. A discussion of the scope and objectives of the larger research effort from which the present study developed is presented in PRA SRR-69-12: The development and evaluation of training methods for Group IV personnel: I. Orientation and implementation of the Training Methods Development School (TMDS) by John Steinemann, October, 1968.

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SUMMARY AND CONCLUSIONS

Problem

Currently, many personnel entering the Navy are unable to demonstrate the degree of competency in basic communication and computational skills necessary to succeed in most Navy ratings. To utilize these personnel productively, new and more effective training methods are needed.

Background and Requirements

Military personnel with preinduction scores on the Armed Forces Qualifications Test (AFQT) that fall within the 10-30 percentile range are categorized as Group IV. Because of the Navy's concern with difficulties experienced in training these personnel, an investigation is being conducted to determine the nature of their difficulties and to identify optimal approaches for improving training effectiveness. As part of this effort, a "self-study" course in mathematics was developed and found to be effective. The present investigation varies conditions of presentation and examines resulting levels of criterion achievement.

Approach

Students were administered the Practical Arithmetic Self-Study (PASS) course, a collection of instructional materials developed for use with Group IV subjects. PASS covers computational skills up to a ninth grade level of difficulty. Three types of modifications were introduced and evaluated. These included providing audio instruction, minimizing direct assistance, and increasing study time.

Findings

By using PASS course materials, approximately one full grade level of improvement was achieved with 15 to 24 hours of instruction. Supplementing or replacing portions of printed instruction with audio presentations did not increase gains but may have caused some trainees to work with greater independence. Elimination of direct assistance from instructors was achieved without a corresponding decrease in performance, and attitudes remained generally positive. Increasing training time from 15 to 24 hours allowed more trainees to complete more of the coursework and resulted in significantly higher gains. However, only about half of the trainees achieved a ninth grade level of performance, which was considered necessary for the types of skills Group IV personnel would be expected to perform within the Navy. Few of those whose initial level of performance was below the seventh grade level achieved a ninth grade criterion performance regardless of how much coursework they completed. It was concluded that remedial

training methods are not yet effective enough to provide many of the Navy's Group IV personnel with an adequate background in general computational skills. Alternatives for dealing with such performance deficiencies are discussed.

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COMPUTATIONAL ACHIEVEMENT OF GROUP IV TRAINEES WITH A SELF-STUDY FORMAT: EFFECTS OF INTRODUCING AUDIO, WITHDRAWING ASSISTANCE, AND INCREASING TRAINING TIME

A. Introduction

Personnel whose preinduction test scores on the Armed Forces Qualifications Test (AFQT) fall within the 10-30 percentile range are categorized as Group IV personnel. Since such personnel are typically deficient in such basic academic skills such as reading, writing, and arithmetic computation, they often perform poorly in Navy training situations.

An experimental facility was implemented for observing and evaluating Group IV performance under controlled conditions (Steinemann, 1968). At this facility, training programs were developed and evaluated.

This is the third in a series of reports concerning the development and evaluation of methods for training Group IV personnel in basic mathematical operations. From an initial assessment of performance, it was determined that an individualized approach was required (Main, 1969). This led to the development of the Practical Arithmetic Self-Study (PASS) course, which has subsequently been published as an instructional manual (Main, 1973). Through the use of PASS course materials, Group IV trainees achieved significant performance gains with approximately 15 hours of study time.

Instructional gains are not, however, the only basis for judging the adequacy of an instructional program. Gains produced through remedial instruction must be balanced against the effort involved in producing them. Reports of success in remedial training are often disappointing when the magnitude of the effort is considered. For example, sponsors of a 3½ month high school summer program to provide remedial instruction to volunteer minority students reported gains in computational performance of half a grade level as being highly successful (Steptoe, 1967).

Even where gains can be produced with relative efficiency, resulting levels of performance may still be unsatisfactory. Jensen (1969) has noted that, in terms of producing meaningful changes in scholastic achievement, most remedial training programs must be considered unsuccessful. In the case of the PASS course, a ninth grade level of computational performance was selected as a criterion for training effectiveness. This criterion was considered to be a meaningful level of performance since the skills involved are relevant to such tasks as recipe conversion and measurement of linear dimensions, the types of tasks which Group IV personnel might be expected to perform while in the Navy. Unfortunately, despite the achievement of significant gains, a sizable proportion of the Group IV sample was unable to achieve a ninth grade criterion on completion of training (Main, 1969).

Since the initial presentation of PASS course instruction did not produce the desired levels of achievement, an attempt was made to identify efficient methods for enhancing the effectiveness of this training. Results of an unsuccessful attempt to increase gains by supplementing PASS course materials with an application of flash card instruction have already been published (Main, 1970). In the present study, a number of other modifications were introduced and evaluated. These included the introduction of two types of audio instruction and changes in training time and levels of instructor assistance. The purpose of the study was to determine (1) whether these modifications can improve the effectiveness of PASS course instruction, and (2) whether the resulting remedial program will be sufficiently effective to raise performance to criterion levels of proficiency.

B. Experiment I: Audio Supplement

The introduction of an audio format of presentation was based on evidence that Group IV personnel could improve their computational performance when the verbal content of arithmetic word problems is simplified or eliminated (Main, 1969). Since audio instruction could be used to reduce reading requirements, it was reasoned that its adoption into the PASS course might facilitate learning.

1. Method

a. Subjects. All of the Group IV trainees who participated in the following experiments were Navy enlisted personnel who had just completed recruit training. Thirty-three trainees participated in Experiment I. Their AFQT percentile scores ranged from 11 to 28, with a mean of 19.2.

b. Materials. The basic instructional materials used throughout this study were contained in the PASS course. They included (1) a series of 25 separate lessons covering operations with whole numbers, fractions, decimals, and percentages, and (2) computations involving units, formulas, linear equations, and ratios. Back-up materials were also provided to keep students occupied if they finished the course in less time than that allowed for the experiment.

In this first experiment, audio tapes were prepared that repeated the instructions and explanations found in the written course materials. Two sets of computational operations were selected for taping: Lesson Set F covered operations with fractions and Lesson Set D covered operations with decimals and percentages.

Two tests were used to evaluate performance. One of these, the USAFI III Arithmetic Computational Test, is commonly used by the military services to establish performance levels for marginal personnel. It has the advantage of providing scores which may be

converted into school grade achievement levels up to the ninth grade. Two parallel forms (A and B) were used in this experiment. The other test, the Arithmetic Operations Quiz (AOQ), was specifically designed to parallel the USAFI test items and allow a more thorough diagnostic evaluation of student performance. A copy of the AOQ is displayed in Appendix A.

Lesson Set F included 12 items from the USAFI test and 11 items from the AOQ test. Lesson Set D included 9 items from the USAFI test and 14 items from the AOQ test. From the performance of previous classes, it had been established that the levels of difficulty of the test items covering the two sets of audio instruction were roughly equivalent.

The questions developed to assess trainees' attitudes and level of motivation are included in Appendix B.

c. Procedure. Participants were from four differenct training sections, each consisting of eight or nine trainees. Each section was trained separately, receiving 3 hours of instruction per day for 5 days. After the first and second hours of instruction, a 10-minute study break was provided. In general, trainees worked independently, completing one lesson at a time and taking a quiz upon completion of each lesson. However, a trainee could take a quiz without completing a lesson and proceed to a new lesson if his performance was satisfactory. The instructor provided assistance, graded quizzes, and required trainees to rework missed quiz items. Trainees were allowed to go on to a new lesson only when they were able to correct their errors.

Within each section, trainees were randomly assigned to one of two treatment groups. One group received the audio supplement for Lesson Set F, and the other, for Lesson Set D. (Both groups received the standard presentation for the remainder of the course.) The experimental design is indicated in Table 1.

TABLE 1

Experimental Design for the Parallel Audio Experiment

	With Audio	Without Audio
Lesson Set F (Fractions)	Group 1	Group 2
Lesson Set D (Decimals & Percents)	Group 2	Group 1

Trainees were administered the USAFI and AOQ tests both before and after training. For two sections, half of the trainees in each treatment group received USAFI Form A as a pretest and Form B as a posttest, and the other half received the reverse. For the other two sections, the USAFI Form B tests were not available so Form A was used both before and after training. This deviation in use of test forms was not a serious problem since both treatment groups were equally affected.

2. Results

In determining performance scores, only those USAFI and AOQ test items that were covered by the instruction presented in Lesson Sets F and D were considered. For each trainee, gain scores were computed separately for Lesson Set F and Lesson Set D items. Each gain score was calculated by subtracting the number of correct pretest responses from the number of correct posttest responses. Two mean gain scores and their standard deviations were then computed for each treatment group, one for items in Lesson Set F, and one for items in Lesson Set D (see Table 2).

TABLE 2

Mean Gain Scores for Lesson Sets Administered With and Without Audio*

	With Audio	Without Audio
Lesson Set F $\bar{X}$ (SD)	Group 1 (N=16)	Group 2 (N=16)
	3.0 (2.19)	2.6 (2.37)
Lesson Set D $\bar{X}$ (SD)	Group 2 (N=16)	Group 1 (N=16)
	2.5 (3.59)	3.2 (3.15)

Note--*One additional trainee was eliminated from the data analysis since he failed to complete any of the coursework covered by audio instruction.

Effects of receiving instruction with and without audio were compared by use of a cross-over design, a special adaptation of a Latin Square analysis with repeated measures (Edwards, 1960). The implementation of this design allowed all participants to be represented under both conditions of course presentation (with and without audio). Results of the analysis are presented in Appendix C. Differences in

gains achieved with and without audio were not found to be significant.

Distributions of responses to an anonymous questionnaire are presented in Appendix B. In general, it appears that trainees were positively motivated by the course. The great majority of responses tended to indicate that attitudes toward mathematics study had improved, the self-study format of instruction was preferred over typical classroom lectures, the length of study sessions was reasonable, and the audio instruction was preferred over the unmodified coursework. A majority of the respondents indicated that they read all workbook explanations carefully most (but not all) of the time.

3. Discussion

Despite the fact that a large majority of trainees preferred audio-supplemented instruction, addition of audio did not affect test performance. The failure of the audio supplement may, in one sense, testify to the success of the basic PASS course materials. The PASS course was designed to provide instruction with low verbal content, and this may have been sufficient to meet the requirements of Group IV trainees.

Attitudes expressed toward course materials and procedures were generally positive. The fact that a majority of respondents indicated that they did not always read workbook explanations carefully before they worked the problems is not viewed as a negative indication. Efficient use of instructional materials demands some degree of selectivity on the part of the learner.

C. Experiment II: Audio Replacement

In Experiment I, implementing audio to reduce reading requirements failed to improve performance. In Experiment II, audio was used to reduce the visual complexity of presentations. By replacing printed instructions with audio, solutions to multi-step problems could be presented with greater clarity and unity.

1. Method

a. Subjects. Thirty-eight trainees participated in Experiment II. AFQT percentile scores for these personnel ranged from 11 to 30, the mean score being 19.8.

b. Materials. Again, the written PASS course materials were used as a standard form of presentation. An audio version was provided for portions of the course covered by Lesson Sets F and D.[1] The audio

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[1]Minor improvements and corrections were introduced following Experiment I but the course basically remained the same.

version differed from that of Experiment I in that much of the written instructions and explanations were eliminated and reproduced on audio tape rather than being presented both in written and in the audio format. Sample portions of the standard and audio versions are displayed in Appendix D. Test materials were the same as those used in Experiment I except that Form A of the USAFI III served both as pretest and posttest.

c. Procedure. Participants were from three different training sections, each consisting of from 11 to 14 trainees. Within each section, trainees were randomly assigned to one of two treatment groups. In contrast to Experiment I, however, one group served as a control and received only the standard written materials. The other received the audio version both for Lesson Sets F and D.

Each section was trained separately, following the same general training and testing procedures implemented in Experiment I. In Experiment II, however, Form A of the USAFI III test was used both as a prestest and a posttest to provide a more sensitive measure of changes in performance. It is considered unlikely that the utilization of a single test form provided any advantage to the trainees since a comparison of gains achieved in Experiment I revealed no differences between those who were retested on the same or on different forms (t = .1, df = 29, p > .05).

2. Results

Using the same calculation procedures described in the results section of Experiment I, gain scores covering performance on Lesson Sets F and D were computed for each trainee. Mean gain scores were then computed separately for the two treatment groups.[2] For the 17 trainees who received only the standard written materials, the mean gain score was 8.8 (SD = 4.31). For the 18 trainees who received the audio version, the mean gain score was 7.2 (SD = 3.83). Applications of t-tests revealed that, while both groups acieved gains that were significant at the .001 level, differences between gains were not significant (p > .05).

Because a control group was provided in this experiment, it was possible to determine whether the effects of audio were measurable in terms of overall course performance rather than in performance over Lesson Sets F and D. Such a result might be expected if trainees were saving time on portions of the course covered by audio and were consequently able to devote more of their time to the portions not covered by audio.

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[2]Scores of three of the trainees were not included in these computations since they did not receive any of the instruction covered by Lesson Sets F and D.

Mean gain scores covering all test items were computed for both groups. The 17 trainees who received the standard course materials had an overall mean gain score of 13.9 (SD = 6.44). The 18 trainees who received the audio materials had an overall gain score of 11.2 (SD = 6.28). Applications of the t-test revealed that while both groups achieved significant gains at the .001 level, differences between groups were not significant ($p > .05$).

Another point in question was whether the audio treatment caused trainees to work with greater independence. A measure of independence was provided in terms of the number of questions trainees asked. In working portions of the course covered by audio instruction, those 17 trainees who did not receive audio averaged 3.1 questions per trainee (SD = 4.28). The 18 trainees who received the audio-modified course work averaged 1.2 questions per trainee (SD = 1.83). Because of the magnitude of the differences in standard deviations, an F-test was performed on the ratio of the variances and found significant at the .01 level. A visual inspection of the data revealed that several of those trainees who did not receive audio asked a disportionately large number of questions.

Following completion of the posttests, an attitude questionnaire was administered. The distribution of trainees' responses are presented in Appendix B. Responses of those who did or did not receive audio were quire similar and, for the most part, were in accordance with the findings of Experiment I. Trainees continued to be generally positive toward the PASS course basic materials and administrational procedures and to be selective in their attention to workbook explanations. Attitudes toward the use of tape recorders were not as generally favorable as those expressed in Experiment I. Thus, it was possible to examine the relationship between attitudes and performance. Only 3 of the 11 trainees with pretest scores above the seventh grade level (27%), as compared with 6 of the 7 trainees with pretest scores below the seventh grade level (86%), indicated a preference for the audio instruction. Application of a chi-square test revealed this difference to be significant ($X^2 = 5.86$, $p < .05$).

Relating attitudes to posttest achievement, one of the nine trainees who achieved the ninth grade criterion (11%), as compared with eight of the nine trainees who did not (89%), indicated a preference for the audio. Again, the difference is significant ($X^2 = 27.56$, $p < .01$).

A new item was added to the questionnaire for Experiment II. Trainees were asked how careful they were about making sure they understood why they made an error before they proceeded to new material. The large majority of trainees indicated that they always did this. These responses contrast with informal reports from instructors who had indicated that Group IV trainees appeared to be careless about checking and correcting errors.

3. Discussion

Again, the addition of audio instruction did not improve test gains beyond the levels achieved with the printed PASS course materials. The only difference found between groups was in terms of the number of questions asked. Some trainees who did not receive audio asked a relatively large number of questions. Since none of those who did receive audio asked such large numbers of questions, it is possible that the taped instructions did influence dependent trainees to work with a greater degree of autonomy.

In general, both treatment groups responded similarly to the attitude questionnaire. A majority of the trainees indicated that they (1) now felt better about working with mathematical problems, (2) read all explanations carefully (at least most of the time), (3) preferred self-study to lecture type instruction, and (4) considered the 3-hour work period to be a reasonable length of time.

In Experiment I, the majority of trainees preferred the audio treatment where printed materials were supplemented with audio tapes. In this experiment, opinions were more divided. Replacement of printed instruction with audio was most frequently objected to by the higher performing trainees, possibly because it prevented them from being selective in their coverage of the coursework.

D. Experiment III: Withdrawal of Assistance and Extension of Training Time

Since the application of audio instruction had not established any performance advantages, efforts were directed at determining the levels of performance effectiveness that could be obtained with the standard PASS course materials by varying the levels of assistance provided to students and training time. In Experiments I and II and in previous studies of Group IV performance with PASS course materials, instructors had spent a large proportion of their time providing direct assistance, showing trainees how to work missed quiz problems and explaining any operations that appeared to cause them trouble. Since the elimination of direct assistance would allow instructors to work with larger numbers of students, it was considered desirable to determine whether this procedure could be followed without adversely affecting performance.

In assessing the effects of reductions in assistance, it is relevant to consider the dimension of training time. Although the PASS course was designed for self-paced individualized study, practical considerations necessitated limiting total study time. As a result, many trainees were unable to complete the coursework. It was questioned, therefore, whether increases in training time would result in higher performance gains and compensate for any losses that might occur when levels of assistance were reduced.

1. Method

a. Subjects. Ninety-three trainees participated in Experiment III, including the 38 trainees referred to in Experiment II.[3] AFQT percentile scores for these personnel ranged from 11 to 30, the mean being 20.0.

b. Materials. Training and evaluation materials were the same as those described in Experiment II.

c. Procedure. Participants were from seven different training sections, including the three sections that participated in Experiment II. Those three sections had received 15 hours of instruction with direct assistance from instructors. The remaining four sections received training without direct assistance and in the following manner: when trainees indicated that they didn't understand how to work a problem, the instructor did not demonstrate the solution, but referred the student to the portion of the course where that particular type of problem was covered. The same instruction materials used in Experiment II were used in Experiment III, but trainees could choose whether or not they wished to use the audio materials.

2. Results

Gain scores covering all USAFI and AOQ test items were computed for each trainee in the manner described in Experiment II. Mean gain scores were then calculated for the three treatment groups. For the 38 trainees who participated in Experiment II and received 15 hours of instruction with direct assistance from instructors, the mean gain score was 12.1 (SD = 6.27). For the 30 trainees who recevied 15 hours of instruction without direct assistance, it was 9.9 (SD = 7.70). For the 25 trainees who received 24 hours of instruction without direct assistance, it was 14.4 (SD = 7.26). Application of t-tests revealed that each of the above gains was significant at the .001 level.

A t-test performed to compare mean gain scores for those who received 15 hours of instruction with and without direct assistance revealed no significant difference ($p > .05$). The two groups that received 15 hours of instruction were, therefore, combined for comparison against those who received 24 hours of instruction. The mean gain score for the 68 trainees who received 15 hours of instruction was 11.2 (SD = 6.99). Application of a t-test revealed that this gain score was significantly smaller than that of the

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[3]The three trainees who were dropped from Experiment II were included in Experiment III since their lack of involvement with instruction covered by audio was not pertinent to the latter study's performance comparisons.

group that received 24 hours of instruction ($p < .05$).

Because of the breadth of the subject matter and the low initial performance of some trainees, many were unable to complete the entire course. Of the 68 trainees who received 15 hours of study, only 8 (12%) completed the course. In comparison, of the 25 trainees who received 24 hours of study, 12 (56%) completed the course. The magnitude of this difference is highly significant ($X^2 = 19.83$, $p < .001$).

Since the USAFI scores are translatable into school grade levels, it was also possible to analyze performance in terms of grade level achievement. Average grade levels of performance before and after training, and mean grade level gains are presented in Table 3. Application of t-tests revealed that gains in grade level were significant at the .001 level for all three conditions of instruction.

In Table 4, trainee achievement is evaluated in terms of the proportion of trainees who attained particular grade levels of performance. The ninth grade level was achieved by one-third to one-half of the trainees. The eighth grade level was achieved by approximately two-thirds and the seventh grade level by three-fourths of the trainees. While these rates of achievement are fairly stable over conditions of training, they vary dramatically depending on the trainees' initial level of performance. A large proportion of those starting at the seventh and eighth grade levels achieved ninth grade criterion. However, most of those starting at or below the sixth grade level failed to attain even an eighth grade level of performance.

Grade level achievement was also analyzed as a function of course completion. The results of this analysis are graphically depicted in Figure 1. While rates of criterion achievement generally increase as a function of level of course completion, differences are apparent between the achivement patterns of those with high and low initial grade levels of performance. For trainees who completed 21 or more lessons, nearly 90% of those who started at the seventh or eighth grade level, but less than 20% of those who started at or below the sixth grade level achieved the ninth grade criterion. Less than 50% of this latter group were able to achieve an eighth grade level of performance.

Questionnaire responses for the three experimental groups are compared in Appendix B. In general, response distributions were highly similar. The majority of respondents in each group indicated that they felt better about working with mathematical problems, read all explanations (at least for most of the time), preferred the self-study format over classroom lecture, and felt that three hours was a reasonable length of time for a study session.

Trainees who worked without assistance tended to be more neutral in their reactions to the audio coursework. Only 3 of the 18

TABLE 3

Mean Grade Level Achievement Before and After Training

Conditions of Instruction	N**	Grade Levels of Performance* PRE Mean (SD)	POST Mean (SD)	GAIN Mean (SD)
15 Hours With Assistance	33	6.9 (1.20)	7.6 (1.34)	.8 (.82)
15 Hours Without Assistance	26	6.8 (.98)	7.7 (1.11)	1.0 (.87)
24 Hours Without Assistance	24	6.8 (1.10)	7.8 (1.37)	1.0 (.86)

Note--

*Scores below the sixth grade level on the USAFI III are not further differentiated. For the purpose of this analysis, they are interpreted as a fifth grade level of performance.

**The 11 trainees whose initial performance was at the ninth grade level were not included in this analysis.

TABLE 4

Cumulative Percentages of Trainees Who Achieved Criterion At Specified Grade Levels of Performance

Conditions of Training	Initial Grade Level	N	Final Grade Level 9th	8th	7th
15 Hours With Assistance	7th to 8th	17	71%	94%	100%
	6th or below	16	6%	25%	56%
	Combined	33	39%	61%	79%
15 Hours Without Assistance	7th or 8th	15	47%	87%	100%
	6th or below	11	9%	27%	73%
	Combined	26	31%	62%	89%
24 Hours Without Assistance	7th or 8th	13	77%	92%	92%
	6th or below	11	9%	36%	64%
	Combined	24	46%	67%	79%

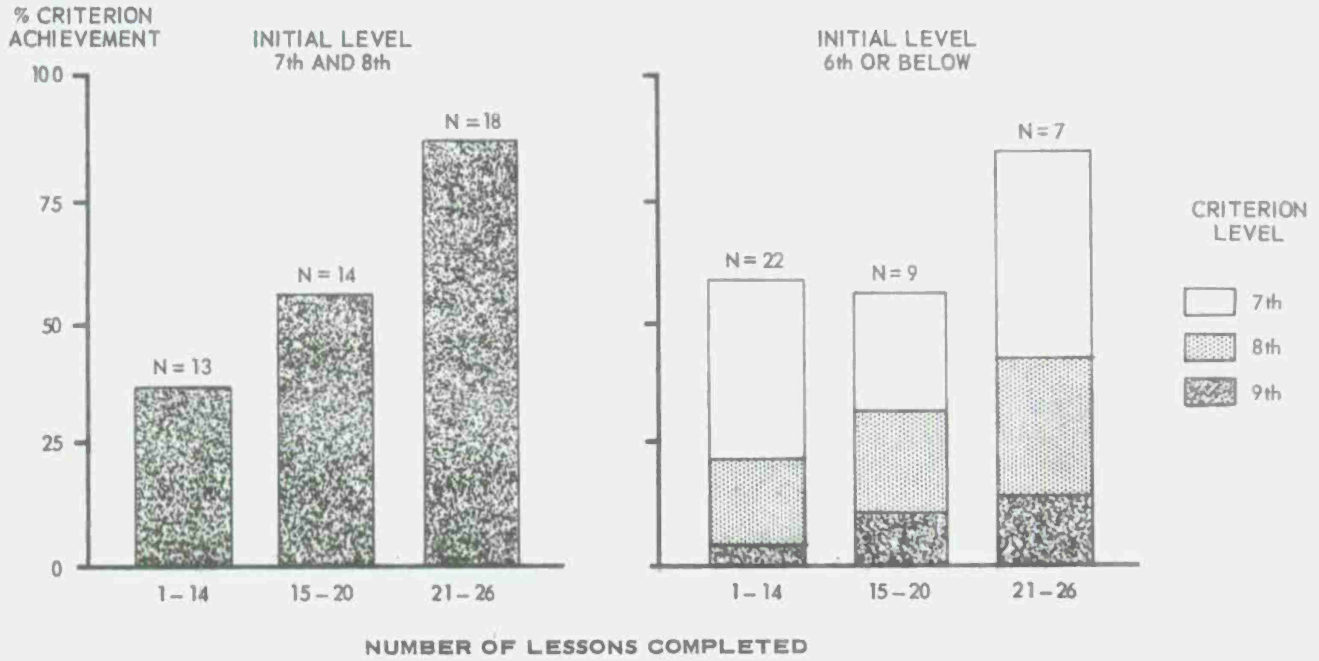

Figure 1. Rate of criterion achievement for trainees with differing final levels of course completion.

respondents who received assistance (17%), but 20 of the 42 respondents who did not (48%) gave a neutral response ($X^2 = 5.11$, $p < .05$). Trainees who did not receive assistance also appeared to be somewhat less careful about checking their work. Only 16 of the 55 respondents who did not receive assistance (29%), but 27 of the 38 respondents who did (71%) indicated that they always found out how to work missed workbook problems before going on to a new lesson ($X^2 = 15.91$, $p < .01$).

3. Discussion

Results of Experiment III indicate that Group IV trainees' level of computational performance can be improved to a considerable extent within a relatively brief time period, even with highly independent conditions of study. In classes of trainees with initial levels of performance ranging from below the sixth grade level up to the eighth grade level, approximately one-third were raised to a ninth grade level of performance with as little as 15 hours of training.

Increasing training time from 15 to 24 hours allowed more trainees to complete more of the coursework and resulted in significantly higher gain scores. Almost half of the trainees who received 24 hours of instruction achieved the ninth grade performance criterion. The average gain in grade level for the experimental groups amounted to as much as a full year's difference in performance.

Elimination of direct assistance did not measureably reduce training effectiveness nor seriously detract from the generally positive

attitudes that prevailed throughout the training sessions. It was noted, however, that trainees who did not receive direct assistance were less diligent in reviewing missed workbook problems.

Although audio was not introduced as a variable in this experiment, some differences in the attitudes of the experimental groups toward the use of audio was observed. Trainees who could choose whether or not to use audio-modified materials were more neutral in their reactions than those who were required to use these materials.

Even with 24 hours of study, many of the trainees did not complete all of the coursework. While criterion achievement was strongly related to levels of course completion, the nature of the relationship was, to a considerable degree, dependent on initial levels of performance. Almost all of those who started at the seventh and eighth grade levels achieved the ninth grade criterion if they completed most of the coursework. In contrast, few of those who started at or below the sixth grade level achieved even an eighth grade criterion.

E. General Discussion and Conclusions

The performance gains achieved in the present study are impressive considering the modest levels of time and assistance that were involved. Whether PASS course instruction is sufficiently effective to prepare the Group IV trainee for his career in the Navy is less certain. Although performance levels were raised by as much as a full grade level, less than half of the trainees involved in the study were able to achieve a ninth grade criterion level of performance.

Most of the operations that must be mastered to achieve a ninth grade level of computational performance appear to be relevant to the types of skills that Group IV personnel would be expected to perform within the Navy. In order to optimize the effective utilization of these personnel, some account of their limitations will have to be taken. One possibility is a selective recruitment and assignment of Group IV enlistees. A seventh grade level of performance appears to be an excellent cut-off point for distinguishing between those who are and are not capable of achieving a ninth grade criterion through use of PASS course materials.

Another possibility worth investigating is whether higher performance levels may be achieved by limiting training to a single occupational area. In the present study, instruction encompassed a broad variety of computational operations with applications to many different types of tasks. While this may be a reasonable approach for providing training to personnel who have not yet been given an occupational assignment, a more specific vocational orientation is possible once assignment has been made. The Group IV trainee might be expected to achieve a higher level of proficiency under such a vocational orientation. For one thing, a smaller set of operations would probably be involved. For another, it would be easier to represent abstract concepts in terms of concrete values and physical

manipulations. Group IV personnel appear to lack a conceptual orientation, and efforts to emphasize the physical correlates of computational operations might be particularly appropriate.

Finally, if a general background in computational skills is determined to be a necessity and selective recruitment is not feasible, more effective training approaches will have to be developed than those described in the present study. It is not immediately evident, however, how training effectiveness can be enhanced beyond the levels already achieved. Increasing study time raised performance gains by allowing more trainees to complete the coursework. However, many of those who completed most of the coursework were still unable to achieve target criterion levels of performance. Efforts to improve the effectiveness of coursework through the introduction of modifications involving flashcards and audio have also been unsuccessful.

It is felt that further progress will require a determination of the nature of the difficulties that the Group IV trainees experience in learning to perform computational operations. Some preliminary insights were provided by those who worked with the trainees in the present study. They observed that the Group IV trainee often appears unable to handle information effectively, i.e., to follow directions, to retain knowledge, and to monitor the correctness of his own performance. These opinions may be worth evaluating. The ability to handle information effectively and efficiently is critical in the development of any type of academic or vocational skill. Efforts to identify and/or improve such abilities could prove relevant to performance in a broad variety of Navy task areas.

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APPENDIX A

The Arithmetic Operations Quiz

APPENDIX A

Arithmetic Operations Quiz

1. $\begin{array}{r} 205 \\ \times\ 302 \\ \hline \end{array}$	2. $10{,}000 \times 100 =$
3. $10{,}000 \div 100 =$	4. $8\overline{)984}$
5. $7\overline{)715}$	6. $6\overline{)700}$
7. Canceling $5 \times \frac{n}{5}$ we get	8. $7 \times 5 =$ ____
9. $6/8 =$ ____	10. $4/5 - 2/5 =$ ____

1.
(a) 61,910
(b) 6,560
(c) 8,000
(d) NG

2.
(a) 100,000
(b) 10,000,000
(c) 10,000
(d) NG

3.
(a) 1,000
(b) 100
(c) 10
(d) NG

4.
(a) 114
(b) 123
(c) 112
(d) NG

5.
(a) 102 r 1
(b) 12 r 1
(c) 10 r 5
(d) NG

6.
(a) 1,000 r 1
(b) 100 r 1
(c) 116 r 4
(d) NG

7.
(a) $\frac{5n}{1}$
(b) $\frac{5n}{25}$
(c) $\frac{n}{5}$
(d) NG

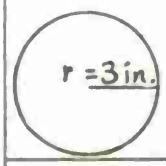
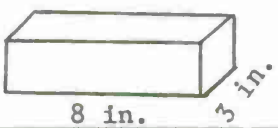
8.
(a) 1/7 ÷ 5/7
(b) 7/1 x 5/1
(c) $\frac{1}{7 \times 5}$
(d) NG

9.
(a) 2/4
(b) 3/2
(c) 1/2
(d) NG

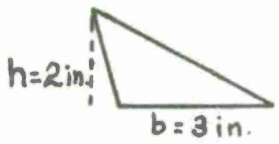
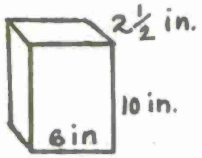
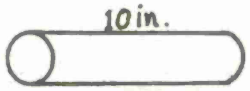
10.
(a) 6/5
(b) 2/10
(c) 2/5
(d) NG

11. 1 3/4 = ____	12. 14/3 = ____	11. (a) 7/4 (b) 3/14 (c) 13/4 (d) NG	12. (a) 11 1/3 (b) 4 2/3 (c) 14 1/3 (d) NG
13. 1 2/4 + 2 1/4 = ___	14. 2 3/4 - 1 1/4	13. (a) 4 (b) 3 3/8 (c) 2 1/4 (d) NG	14. (a) 1 2/4 (b) 1 3/4 (c) 1 1/4 (d) NG
15. $5\overline{)8.30}$	16. 9/27 can be reduced no further than ____	15. (a) 1.30 (b) 1.36 (c) 1.66 (d) NG	16. (a) 1/4 (b) 2/3 (c) 1/3 (d) NG
17. 12/21 can be reduced no further than ___	18. Reduce 21/14 and change it to a mixed number.	17. (a) 4/7 (b) 3/4 (c) 8/14 (d) NG	18. (a) 3/2 (b) 1 1/2 (c) 1 7/14 (d) NG
19. .05 X 6 = ___	20. .001 X .01 = ____	19. (a) 3.0 (b) .30 (c) .03 (d) NG	20. (a) .0001 (b) .01 (c) .00001 (d) NG

21. .5 = ____	22. 3/5 = ____	21. (a) 5/10 (b) 5/100 (c) 1/20 (d) NG	22. (a) .3 (b) .5 (c) .6 (d) NG
23. If: X - 10 = 3 Then: X = ____	24. If: 17 - X = 6 Then: X = ____	23. (a) 7 (b) 13 (c) 3/10 (d) NG	24. (a) 6/17 (b) 23 (c) 11 (d) NG
25. If: A = B - C Where: B = 5 & C = 4 Then: A = ____	26. If: 9X = 18 Then: X = ____	25. (a) 9 (b) 20 (c) 4/5 (d) NG	26. (a) 2 (b) 9 (c) 27 (d) NG
27. If: A = B + C Where: B = 2 & C = 3 Then: A = ____	28. If: $A = \frac{B}{C + D}$ Where: B = 10, C = 2 and D = 3 Then: A = ____	27. (a) 2/3 (b) 1 1/2 (c) 2 1/3 (d) NG	28. (a) 1/2 (b) 2 (c) 2/5 (d) NG
29. Bill's test scores were: 100, 50, 80, 70, 60. His average score = ___	30. 3/4 = ____	29. (a) 70 (b) 36 (c) 72 (d) NG	30. (a) 30% (b) 34% (c) 75% (d) NG

31. 5% = ____	32. 25% = _____	31. (a) .5 (b) .05 (c) 5.0 (d) NG	32. (a) 2.5 (b) .025 (c) .04 (d) NG
33. What percent of the square is black? 	34. The edge around this rectangle = ____ 8 in.  4 in.	33. (a) 75% (b) 25% (c) 100% (d) NG	34. (a) 32 sq.in. (b) 12 in. (c) 24 in. (d) NG
35.Circumference = $2\pi r$ π = 3.14 so:  r = 3 in. Circumference equals ___in.	36. The area of this square cornered triangle = _____ 2 in.  4 in.	35. (a) 18.84 (b) 6.20 (c) 9.42 (d) NG	36. (a) 8 sq.in. (b) 4 sq.in. (c) 8 in. (d) NG
37. The volume of the box = ____ cu.in. 2 in.  8 in. 3 in.	38. 6/5 = _____	37. (a) 48 (b) 13 (c) 26 (d) NG	38. (a) 5 ÷ 6 (b) 5/6 (c) 6 · 5 (d) NG
39. 9^2 means ____	40. 6% of 20 = ____	39. (a) 9 X 9 (b) 9 + 9 (c) 2 X 9 (d) NG	40. (a) 20/.06 (b) .06 X 20 (c) 20 ÷ .06 (d) NG

41. 1 2/5 + 3 1/2 = ____	42. 3 3/8 - 1 6/8	41. (a) 4 9/10 (b) 4 2/10 (c) 4 3/5 (d) NG	42. (a) 1 9/8 (b) 1 7/8 (c) 1 5/8 (d) NG
43. 100 ÷ 10,000 = ____	44. 2 ÷ 5 = ____	43. (a) 100 (b) .001 (c) .01 (d) NG	44. (a) .04 (b) .4 (c) .25 (d) NG
45. .25/ .525	46. 50% of 10 + 20% of 10 = ____	45. (a) 2.1 (b) 20.5 (c) 20.1 (d) NG	46. (a) 70% of 10 (b) 70% (c) 270 (d) NG
47. (1/2 of 20)-(25% of 20) = ____	48. Interest paid in 1 year: $30 Rate: 5% Amount borrowed: ____	47. (a) 3/4 of 20 (b) 1/4 of 20 (c) 75% of 20 (d) NG	48. (a) $150 (b) $300 (c) $600 (d) NG
49. Usual price: $24 Discount: 25% Sale price: ____	50. If the price is $20 and the tax is 3%, then you pay ____.	49. (a) $30 (b) $12 (c) $20 (d) NG	50. (a) $23.00 (b) $20.60 (c) $20.30 (d) NG

51. If: 2/X = 4 Then: X = ____	52. If: A = (B + C) Where: A = 20, B = 2, Then: C = _____	51. (a) 2 (b) 8 (c) 1/2 (d) NG	52. (a) 10 (b) 22 (c) 18 (d) NG
53. 5 hr. 20 min. = ____hr.	54. 216 sq.in. = ___sq.ft.	53. (a) 5.2 hr. (b) 25 hr. (c) 5 1/4 hr. (d) NG	54. (a) 18 (b) 12 (c) 1 1/2 (d) NG
55. 2 cubic yds.=___cu.ft.	Area = 1/2 bh 56. Area = ____sq.in.  	55. (a) 27 (b) 54 (c) 6 (d) NG	56. (a) 6 (b) 3/4 (c) 1/3 (d) NG
57. The Volume of the box = ____cu.in.  	58. If the area of the end equals 5 sq.in., the volume of the cylinder equals __cu.in  	57. (a) 18 1/2 (b) 120 1/2 (c) 150 (d) NG	58. (a) 15 (b) 50 (c) 2 (d) NG
59. The ratio of sailors to officers = 20 to 3 for 300 officers we will have ____enlisted men.	60. If you want to travel 400 miles in 8 hrs. your rate of speed must average _____.	59. (a) 45 (b) 60 (c) 2,000 (d) NG	60. (a) 50 mph. (b) 32 mph. (c) 20 mph. (d) NG

APPENDIX B

Distribution of Trainee Responses to the Attitude Questionnaire

APPENDIX B

Distribution of Trainee Responses to the Attitude Questionnaire

Question	Response	EXP I	EXP II		EXP III		
			With Audio	Without Audio	Assisted 15 Hrs.	Not Assisted 15 Hrs.	Not Assisted 24 Hrs.
1. Now that you have completed this course, how do you feel about working with mathematical problems?	a. Still good	4	6	4	11	5	4
	b. Still bad	0	0	2	2	3	4
	c. Better	28	12	11	25	21	17
	d. Worse	0	0	0	0	4	0
2. Did you prefer working with or without the tape recorders?	a. Much better with tapes	11	6	-	6	6	5
	b. Better with tapes	9	3	-	3	5	1
	c. No difference	6	3	-	3	9	11
	d. Worse with tapes	3	4	-	4	2	2
	e. Much worse with tapes	1	2	-	2	0	1
3. Did you read all the explanations in the workbook carefully?	a. Always	14	4	7	11	11	5
	b. Most of the time	12	14	6	22	7	16
	c. If couldn't work problems	5	0	4	5	12	3
	d. As little as possible	1	0	0	0	0	0
	e. Never	0	0	0	0	0	0

APPENDIX B (continued)

Question	Response	EXP I	EXP II		EXP III		
			With Audio	Without Audio	Assisted 15 Hrs.	Not Assisted 15 Hrs.	Not Assisted 24 Hrs.
4. How did you like working on your own instead of having lectures from an instructor?	a. Much better	16	7	10	18	7	8
	b. Better	10	9	1	10	11	11
	c. No difference	5	1	1	3	2	2
	d. Worse	1	0	2	3	5	2
	e. Much worse	0	1	3	4	5	1
5. Was three hours a day a reasonable length of time for study?	a. Should be longer	13	5	3	9	3	1
	b. Just right	18	11	13	26	25	16
	c. Should be shorter	1	0	0	0	1	6
6. When you found you missed a workbook question, did you make sure you understood how to work the problem before you continued?	a. Always	-	12	13	27	8	8
	b. Most of the time	-	6	3	10	19	9
	c. Some of the time	-	0	1	1	3	8
	d. Never	-	0	0	0	0	0

APPENDIX C

Analysis of Variance for Experiment I: An Evaluation of the Effects of Audio

APPENDIX C

Analysis of Variance for Experiment I:
An Evaluation of the Effects of Audio

Source of Variation	Sum of Squares	df	Mean Square	F	Level of Significance
Treatments (With and without audio)	5.06	1	5.06	.79	NS
Columns (Lessons Sets F and D)	5.78	1	5.78	.90	NS
Rows (Ss)	298.75	31	9.64	1.51	NS
Error	192.16	30	5.78		

APPENDIX D

Samples of Standard and Audio Versions of PASS Course Materials Presented in Experiment II

Samples of Standard and Audio Versions of PASS Course Materials Presented in Experiment II

Standard Course B II
Long Division

What happens when we divide into large numbers?

$4\overline{)612}$

The number 612 is so large we can't guess how many times 4 will go into it. In order to solve a problem like this, we have to work with the digits in 612 one at a time.

The first thing we do is see if 4 will go into the first digit in 612 which is 6.

4 goes into 6 1 time with 2 left over.

```
  1
4/612
-4
 2  left over
```

(Notice that since we are dividing 4 into 6 we put the 1 directly over the 6.)

Whenever you divide and get a remainder, bring down the next number.

We bring down the 1 and get 21

```
  1
4/612
-4
 21
```

Now we divide 4 into 21

4 goes into 21 5 times with 1 left over

```
  15
4/612
-4
 21
-20
  1  left over
```

Since we divided we must bring down the next number which is _____.

When we brought down the 2 it gave us 12. Now we divide 4 into 12.

4 goes into 12 3 times with no remainder so we are finished.

```
  153
4/612
-4
 21
-20
  12
 -12
  00
```

Now let's work another long division problem.

Divide 174 by 3.

We can't divide 3 into 1 so try dividing 3 into 17.

3 goes into 17 5 times with 2 left over

```
  5
3/174
-15
 2
```

(Notice we put the 5 over the 7)

What is out next step? _____

After we divide we always bring down the next number.

Bringing down the 4 gives us 24.

3 goes into 24 8 times with nothing left over. So our answer is 58.

```
  58
3/174
-15
 24
-24
 00
```

Audio Course B II
Long Division

What happens when we divide into large numbers?

4/612

We have to work with one digit at a time.

```
   1
4/ 6 1 2
  -4
   2 _
  -_ _
  ----
    _ _
   -_ _
   ----
    _ _
```

Let's try another long division problem. Divide 174 by 3.

```
3/ 1 7 4
  -_ _
  ----
    _ _
   -_ _
   ----
    _ _
```

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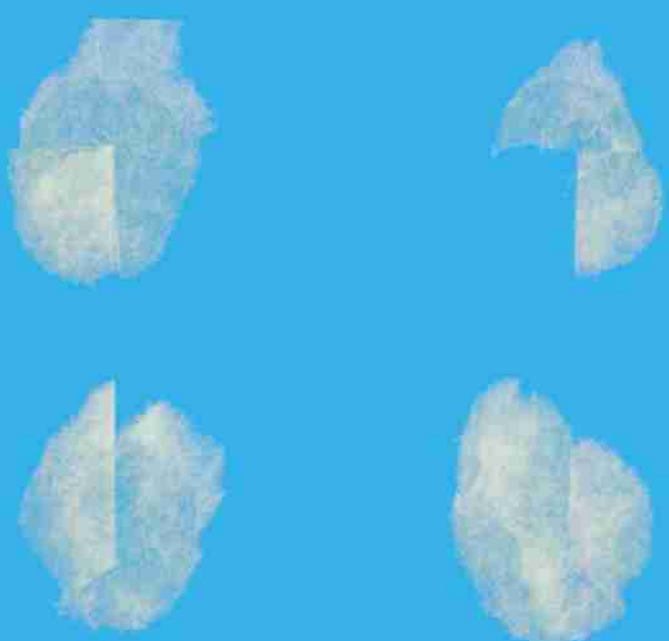

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